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AUTHOR Hiscox, Michael D.; And Others
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ABSTRACT

This synopsis of educational technology concepts and opinions was written as part of a project to investigate how, if, and when innovative technology, particularly videodiscs, should be incorporated into Alaska's educational system. After reviewing the status and methods of educational technology, it is concluded that: (1) educational technologists do not agree on the critical elements of their discipline; (2) educational technology does not have a common knowledge base that can be used to avoid the pitfalls encountered in earlier projects; (3) educational technologists cannot cite large numbers of successful projects which demonstrate the value of their skills; (4) the optimism that was present during earlier educational technology projects is largely gone, replaced by a great concern for the practical; and (5) the success or failure of educational technology projects may depend on factors that cannot be controlled by project developers. It is pointed out that, in the absence of an encouraging history, the decision to support an expanded educational technology in Alaska's schools would be essentially a gamble, based more on future promises than past successes. A checklist of educational planning considerations is appended. (LLS)

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A Synopsis of Educational Technology Design and Implementation Concerns

APRIL 1981

Michael D. Hiscox
Beverly L. Anderson
Evelyn J. Brzezinski

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Assessment and Measurement Program
Northwest Regional Educational Laboratory

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FOREWORD

Alaska has been a leader among State Departments of Education in experimenting with and studying the potential use of new communication technology in education. Since 1977, the Educational Telecommunications for Alaska Project has been investigating and trying out instructional and management uses of technology including an electronic mail system and computer-assisted instruction using microcomputers.

In 1980 the Department decided to fund a feasibility study and then a research project on the potential use in education of innovative technology, particularly videodiscs. This paper has been written as a part of that project.. It is intended for the use of the project's Design Team as they proceed in their deliberations of how, if and when innovative technology should be incorporated into Alaska's educational system.

Readers other than Design Team members should be aware that some terms may be used more loosely than would be done if the paper was intended for other audiences and that reasons for inclusion or exclusion of certain information may not be as apparent to them as it will be to the Design Team.

I. INTRODUCTION

Educational technology--what it is and how to do it--has a base of literature that requires adjectives of the "vast, huge, immense" ilk. If paid by the word, the author of verbiage would find few educational fields more lucrative. It is a troublesome literature to assess in any review, for it contains few well explicated overriding principles. Also, a short summary of where we are and are not in the science of educational technology requires reduction and synthesis of broad issues which cannot be treated effectively in a comprehensive manner in so few pages.

What follows is not, in the traditional sense, a literature review. There is a high probability that it would receive a failing mark from a professor looking for sound documentation of the principles of educational technology. The following report has too few precise citations, too many broad generalizations, and far too few pages to pass as an adequate literature review. Therefore, it would best be viewed as a synopsis of educational technology concepts and opinions. Additional, and more formal, documentation of the information presented can be made available to the Design Team members upon request.

II. EDUCATIONAL TECHNOLOGY DEFINED

There is no shortage of definitions in the literature of what constitutes educational technology. It is an understatement to say that there is no single definition generally agreed upon; in fact, many an educational technology article starts off with the author's unique definition of the term.

Definitions, resulting from a disparity in the principal concerns of the educational technologists themselves, seem to fall into three categories. One school of thought has educational technology focusing on hardware; educational technology is viewed as the use of computers, television, and other equipment in instructional application. But focusing on hardware, as opposed to student learning, is not viewed positively by educators; technologists often find it advantageous to disavow such an orientation. A further problem with this definition is that the question of what hardware constitutes "technology" depends on when the question is asked. Audio tapes, film strips and overhead projectors are not the focus of current educational technology efforts; this equipment is not "advanced enough", so today's progressive educational technologist is concerned with microcomputers, videodiscs and teleconferencing instead. Perhaps for these two reasons, the hardware-oriented definition is not currently in vogue.

A second type of definition focuses on technology principles, rather than products, to delineate educational technology. When principles of modern research, management or accountability are used in an educational setting, the result is often called educational technology. The concept of a "systems" approach is often included in the definition. Through this approach, mastery learning, behavioral objectives and diagnostic

testing become an allowable part of educational technology. This type of definition may create a more positive reaction by focusing on procedures rather than on machines. However, some purveyors of this type of definition seem to suffer withdrawal symptoms, and thus the definitions often contain a "through the use of hardware/media/physical devices" sort of delimiter at the end.

A third type of definition places the focus on development of materials; educational technology thus becomes the body of materials development practice. Virtually every educational technology project focuses on developing, or figuring out how to develop, materials related to instruction. Even the systems approaches mentioned above generally have a body of materials that physically implement the desired concepts. But this type of definition often does not seem sophisticated enough, for most educational technologists think the classification "materials developer" is inadequate to describe the scope of their orientation. Perhaps for this reason, many definitions of educational technology do not acknowledge the task of materials development at all.

In general, educational technologists have failed to agree on the critical elements of their business. This, taken by itself, need not be viewed as negative; other disciplines have moved ahead with fuzzy definitions in tow. The definition problem is, however, somewhat indicative of a larger problem facing educational technology--the inclination to embark from a personal, rather than a professional, starting point. Gropper[1], in writing of the proliferation of instructional theories and models, stated:

> There is no collegial, or even competitive, building of a common knowledge base with individuals making incremental

[1]Gropper, G.L. Is instructional technology dead? Educational Technology, 1980, 20(1), 37-39.

> contributions to it. Instead, there are as many "knowledge bases" as there are contributors. Such profusion, if other sciences serve as a guide, does not argue for the maturity or sophistication of the discipline. (p. 37)

The definition issue discussed above is clearly one example of the lack of a common knowledge base. The literature does not point out this definition problem as a handicap; however, it definitely does not cite the lack of uniformity as an advantage.

For purposes of this paper we will be viewing educational technology as an amalgamation of all three types of definition. We will be concentrating on the instructional uses of educational technology, however, as opposed to management or other uses of the technology.

III. STATUS OF EDUCATIONAL TECHNOLOGY

It is perhaps useful, before considering the development of any large educational technology project, to examine what the people active in the field have to say about the past, present and future state of their vocation. Are creators of educational technology bullish about what can be done? Do they foresee substantial and fruitful application of their work to education? Are they pleased with their "track record" to date?

The educational technology literature is, in many ways, a self report provided by the technologists. Self report information is frequently instructive, but can be misleading if the background and motives of the reporters aren't known. Thus, while it is possible to gain some sense of the status of the field from the literature, it is not possible to say with certainty that the literature truly represents the actual situation. Nevertheless, a review of the recent educational technology literature does impart a definite feel for the current status, history and future of educational technology.

If sweeping generalizations are permissible, one can say the situation does not seem to be good. Based on their own writings, educational technologists are not particularly proud of their past work, their present work lacks the forcefulness they would like it to have, and their view of the future is not optimistic. Some of the technologists' writing expresses pessimism about their ability to develop and implement their systems in a time of increased educational accountability and decreased resources. There are also some indications of a perceived adversarial relationship between educational technologists and school personnel; in and of itself, it is interesting to find that educational technologists do not generally include themselves in the classification "educator".

Level of Success

In January 1980, Educational Technology marked its twentieth anniversary with a special issue composed of essays on the state of educational technology. Essays were provided by eleven authors who are recognized as leaders in the field. In describing the authors, the Educational Technology editor commented:

> Most of the authors have been active in the field for the past two decades. Collectively, they bring an enormous amount of experience to the task of commenting on the current status of educational technology, describing how the field has progressed during the past twenty years, and projecting where we seem to be headed during the coming decade. (p. 56)

What did such noted experts have to say about their profession? George Gordon, in his essay "Happy Birthday, Ed Tech! A Grim Look at Past, Present, Future", stated:

> The picture, in other words, is pretty grim, and whatever role technology has had upon American education these past twenty years, it is minimal and certainly all out of proportion to most of the reasonable promises it held out to our prosperous society in the early 60's. (p. 17-18)

W. James Popham, in "Two Decades of Educational Technology: Personal Observations", writes:

> It is distressingly true that decent educational development, that is, development that produces products which really help students learn more effectively, costs more than most people think. If we ever get a second chance to prove that such development is worth the expenditures, we dare not blow it again. (p. 21)

Dr. Popham goes on to say:

> Unfortunately, that potent technology demands more resources than our nation currently seems inclined to expend. I suspect that a series of unforeseen events must transpire before we find ourselves again in a position to create the technically sound sorts of replicable instructional sequences which will yield dramatic benefits for learners. That we can do it, I have no doubt. Whether, in my lifetime, we will ever be given that opportunity, I am less certain. (p. 21)

In an article titled "The Passion for the Practical: Are Educational Technologists Losing Their Idealism?", Roger Kaufman states that "We are losing our taste for daring to risk to attempt useful change and thus have moved increasingly to the acceptable, the 'practical', and the narrow--we are, in short, losing our idealism." (p. 22) He also opines that:

> If we persist in viewing our field with gloom and doom, then we will surely communicate this feeling to those around us, and they in turn to those around them. If we really believe that we cannot change the world and make it better, if we think we can only react to the desires of our clients, if we use "practicality" as the sole criterion for our interactions with our clients and students, then we deserve to languish in the storm cellars. (p. 23)

George L. Gropper, in an essay with the straightforward title "Is Instructional Technology Dead?" writes:

> If the volume of words published about it is the appropriate vital sign to examine, then it is safe to conclude that instructional technology is still alive. But, is it alive and well? And, does anyone other than the patient care? (p. 37)

He goes on to state:

> Instructional technology suffers from many of the same ills that have in the past and to this day continue to afflict "education" proper. The consuming public, which is large and non-depleting, expects quick and dramatic fixes. Johnny's inability to read and write is serious enough a problem to make each new educational fad appear to it as the answer. So, there is educational film and television, programmed instruction, open classrooms, personalized systems of instruction, the new math, CAI, the systems approach, etc., all playing educational chairs. And, there are a lot of people in instructional technology, and in education, easily encouraged to design a new model. There is no convincing evidence that the chairs they turn out, old or new, appreciably differ from one another in sturdiness or durability. (p. 37)

In the same issue, Leonard C. Silvern writes about a time of educational lethargy (p. 40); and Dwight W. Allan and Lawrence N. McCullough admit that "In the educational technology of the last twenty years, many

approaches to many new technologies have been explored, adopted, modified, and often discarded as haphazardly as they have been institutionalized." (p. 47)

When one considers that these authors make their living and professional reputation through educational technology, and that they were in a way "celebrating" the two decades since the emergence of their field, their comments are indeed significant. In reviewing the recent literature, one has the feeling that educational technologists are both tired and in some ways wary. Kaufman states:

> Gone, by and large, is the push and drive to change the world, and the conviction that if you build a better mousetrap, the world will beat a path to your technology. We now make fewer claims, limit our objectives and rarely catch the spark to change the world. We once had that dynamism! What happened? (p. 22)

Much of the more restrained orientation may be traced to the frequently mentioned phenomenon of technologists overselling the capabilities of their systems. The previous performance of educational technology systems is perceived by many educators and educational technologists as not all that good despite the fact that some very talented people, many with adequate resources, have put considerable effort into making technology work.

Many disciplines have, ingrained into their history, several major successes--applications of the discipline that are so overwhelmingly positive that they serve to help justify all subsequent applications. The elimination of polio, the effective application of plastics, and the beneficial use of computers are occurrences that tend to garner support for future efforts in medicine, chemistry and electronics, respectively. It is probable that the recent fly-by of Saturn will positively impact on

the future of space exploration; the successful Saturn experience will form both a model and a starting point for subsequent efforts.

Perusal of the educational technology literature fails to uncover similar successful examples. The discussions of educational technologists do not seem to include "Remember how well our last project went? Now, let's improve upon that." It would seem incredible that the history of educational technology has not produced projects, concepts or pieces of equipment which technologists can hold up as a shining example of what their science can do. Yet that appears to be the situation. The literature of educational technology development speaks more toward new ideas than to improving what already exists. There seems to be a very large amount of starting from scratch, an amount that perhaps can be explained by a lack of advantageous starting points.[2] None of the major concepts or projects designed to impact instruction (e.g., teaching machines, modern math, programmed instruction, large scale computer-assisted instruction, behavioral objectives, individualized instruction, minimum competencies) have improved education dramatically enough to be considered unqualified successes worthy of honored status. One infers from the literature that, to date, educational technology successes have come at the level of the ERIC system, computerized class scheduling and the use of overhead projectors--handy additions but scarcely revolutionary. Many of the more ambitious efforts clearly teeter on the edge of being adjudged nothing more than fads.

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[2]It may also be that the starting from scratch is due to (1) a lack of knowledge and analysis of what <u>has</u> been done in the past or (2) recognition that one approach may not be universally effective but needs to be tailored to a given context.

Cost

Another important factor to consider in terms of the status of educational technology is cost. Since educators and educational technologists differ in terms of what they are willing to include as assignable project costs, the figures discussed here are useful only to give an order of magnitude feel for the costs of educational development. Here are some of the costs reported in Heath and Orlich's article "Determining Costs of Educational Technology: An Exploratory Review and Analysis"[3]:

- One publisher stated that to develop an elementary reading program for grades K-6 might cost $2,500,000. Yet the total expense of the program could approach $5,000,000. The same report stated that a multimedia high school biology course could range from $400,000 up to $6,000,000.

- Lysaught also stated that to stay within the 5% student error ratio required 30-60 minutes labor per frame of a finished [programmed instruction] program.

- Novak reported that each 15 minute lesson for elementary science required from 50-100 hours of staff time. Some programs, he said, were revised extensively and required up to 200 hours of additional staff and technician time.

- [Lysaught] cited a time factor of from 20 to 30 minutes per item for initial writing, sequencing and the first revision after field testing when the programmers programmed from areas where conventional teaching had been done. He acknowledged that it would take more time to program entirely new material.

- Markle reported that she calculated her "wages" at 50¢ an hour in writing a programmed instruction package.

While the costs above give some idea of the resources necessary, the following table should remove any doubts about the level of effort required for large-scale educational technology development. It is a listing of the curriculum development and concomitant implementation

[3]Heath, S.P, & Orlich, D.C. Determining costs of educational technology: An exploratory review and analysis. Educational Technology, 1977, 17(2), 26-33.

costs for some of the major development projects sponsored by the National Science Foundation. Heath and Orlich termed the costs "awesome", perhaps acceptable hyperbole when one recognizes that all of these costs were incurred prior to 1975--the costs today would be at least 50% higher.

Table 1

Curriculum Development and Implementation
Costs for Selected National Science Foundation Curricula

Curriculum Project	Development Costs	Implementation Costs	Total Documented Costs
Physical Science Study Committee (PSSC)	$ 5,300,000	$6,800,000	$12,100,000
School Mathematics Study Group (SMSG)	$14,400,000	$2,260,000	$16,660,000
Biological Science Curriculum Study (BSCS)	$10,400,000	$9,400,000	$19,800,000
Elementary Science Study (ESS)	$ 7,600,000	$4,100,000	$11,700,000
Science--A Process Approach (SAPA)	$ 2,300,000	$4,900,000	$ 7,200,000
Science Curriculum Improvement Study (SCIS)	$ 4,300,000	$6,700,000	$11,000,000
Intermediate Science Curriculum Study (ISCS)	$ 1,500,000	$5,000,000	$ 6,500,000
Man: A Course of Study (MACOS)	$ 4,800,000	$2,200,000	7,000,000

Source: National Science Foundation Curriculum Development and Implementation for Pre-College Science Education. Report prepared for the Committee on Science and Technology, U.S. House of Representatives, Ninety-Fourth Congress, Washington, D.C.: U.S. Government Printing Office, 1975, pp. 303-308 (Appendix 7).

Implications for Implementation

Formal summaries of "how to succeed where others have failed" articles are not too common in the literature, but the reviewer can infer that many of the factors that prevent success of educational technology projects are either unrelated or in opposition to the principles and procedures of the technology itself. In an obvious example, educational technologists are proud of their ability to develop flashy, innovative systems to solve educational problems. Yet the school settings in which these systems are to be implemented are generally regarded as very conservative. Further, the scientific principles in the technologist's bag of tools are little good in changing the implementation situation.

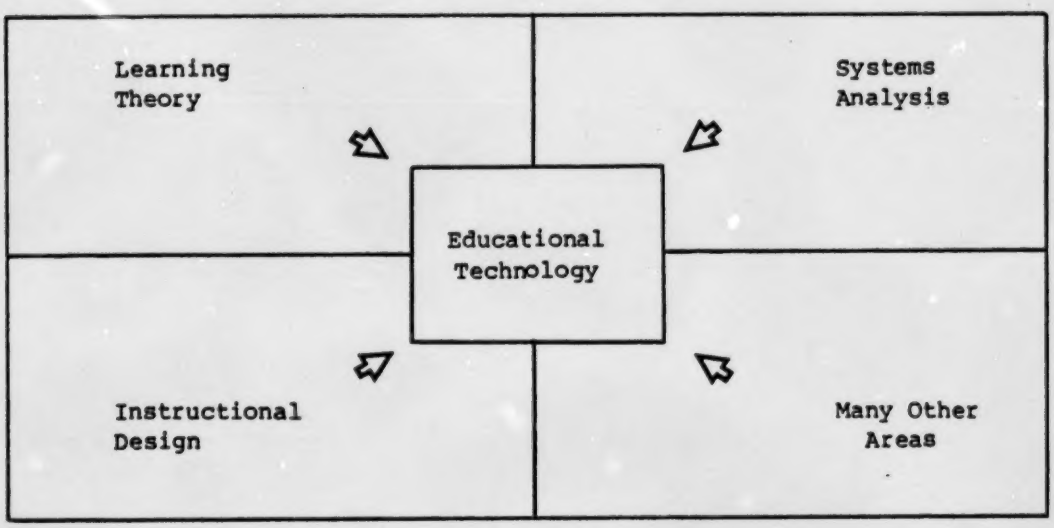
A reviewer of the literature thus becomes a believer in the concept of uncontrollable implementation variables--variables beyond the control of the developer or implementer which will nevertheless impact on the project. Lack of money, teacher conservatism and the general school structure are examples of essentially uncontrollable implementation variables. As the chart below shows, the uncontrollable implementation variables--on their own or combined with other shortcomings--are sufficient to substantially reduce the chance of overall project success.

IF THE DEVELOPMENT IS	AND THE CONTROLLABLE IMPLEMENTATION VARIABLES ARE	THEN THE TECHNOLOGIST WOULD THINK THE PROJECT LIKELY TO	AND IF THE UNCONTROLLABLE IMPLEMENTATION VARIABLES ARE	THE PROJECT AS A WHOLE WILL
Good	Favorable	Succeed	Favorable	Succeed
Good	Favorable	Succeed	Unfavorable	Fail
Good	Unfavorable	Fail	Favorable	Fail
Good	Unfavorable	Fail	Unfavorable	Fail
Poor	Favorable	Fail	Favorable	Fail
Poor	Favorable	Fail	Unfavorable	Fail
Poor	Unfavorable	Fail	Favorable	Fail
Poor	Unfavorable	Fail	Unfavorable	Fail

Subsequent sections of this paper will review the literature in terms of implementation factors, and will consider the design and development factors surrounding educational technology. A section on how to assess a given educational technology project and a checklist summarizing design considerations are also given.

IV. DESIGN CONCERNS FOR EDUCATIONAL TECHNOLOGY DEVELOPMENT

When reviewing the literature for information on how best to design a technology-based product, one finds that the same principles and guidelines given in learning theory articles appear in the educational technology articles, and that guidelines and principles from instructional design are part and parcel of educational technology design. Also, the authors of educational technology literature are frequently found to be the writers of articles on the associated topics. This situation may be a result of the lack of a clear definition of what constitutes educational technology. Or, more probably, it is simply the case that learning theory, instructional design, etc., are the component parts of educational technology, somewhat as shown in this diagram:



It is apparently true, if one believes the literature, that the concerns about developing sound instruction should and will overwhelm the technological concerns. Indeed, it appears that in many projects the technology never had a chance to be evaluated because the instructional design or the implementation was faulty. Currently technology is often applied to products and processes which could not succeed regardless of the quality (even perfection) of the technological elements. The literature supports the contention that technology should be used to enhance the solution of an educational problem, rather than using education as simply an opportunity to apply a favorite technology.

In 1977, Dr. F. Coit Butler of the University of Massachusetts published a paper titled "The Major Factors That Affect Learning: A Cognitive Process Model."[4] Dr. Butler's process serves well to summarize the major concerns that should be considered in designing technology-based educational products since it contains most of the elements discussed by others and avoids a focus on one particular element. It should be pointed out that several other authors could have provided similarly satisfactory starting points.

Dr. Butler's process cites a number of points related to each of seven major conditions for learning:

1) Variation

2) Motivation

3) Organization

4) Participation

---

[4]Butler, F.C. The major factors that affect learning: A cognitive process model. Educational Technology, 1977, 17(7), 5-12.

5) Confirmation

6) Repetition

7) Generalization

In the following listing, the titles of the conditions and the relevant points have been modified slightly from Butler's paper to be more directly related to technology design considerations.

Variation

- The parameters of any learning situation are the characteristics of the learners themselves.
- Effective instruction must allow the student to start from an appropriate point; it is clearly inappropriate to expect all students to start their instruction from the same point.
- Factors such as the student's attitude, motivation and interest greatly affect the ability to learn; most researchers now consider these things more important than general mental ability.
- In spite of the fact that students come into an instructional setting with a set of characteristics, none of these characteristics is a fixed attribute. Thus, while instruction should account for individual differences, it must also allow for changes in the student's characteristics during instruction.
- Efforts to determine what might be called the student's learning style have not been overwhelmingly successful. (Butler states, "The state of the art at this time is such that we are probably wasting our time and resources trying to devise instruction exactly suited to the learning needs of each individual student.")
- While not all individual differences can be handled fruitfully in designing instruction, most researchers agree that consideration of a few elements greatly improves the instruction with regard to students' individual differences. (Butler lists identification by students of their strengths, deficiencies and goals; the quality of instruction; and the time allowed for learning.)
- Of the important variables, time allowed for learning is believed by many to be a most critical factor. The research suggests that individual differences tend to cause fewer negative effects when students are given time to learn at the rate best for them (i.e., as much time as they need to master the content).

- The research also suggests that there is no overall "aptitude for learning"; rather, many factors (some of which are uncontrollable and perhaps unknowable) contribute to the ability to learn.

- Given the two statements above, "learning aptitude" may in part be considered to mean the amount of time needed to achieve proficiency at a task.

- While the amount of time required is very important, learning is still greatly affected by the quality of the instruction and the multitude of other individual differences among students.

Motivation

- Not much will be learned unless the student wants to learn. Learning will only take place if the student pays attention to what is going on in the learning environment.

- The student's attention seems to be directly related to the student's motivation. More motivation, more attention--and thus more learning.

- Instructional materials must allow not only for providing initial motivation, but for sustaining motivation throughout the task. If the student's motivation decreases, the amount of learning is also decreased.

- Stating the outcome of a learning task in concrete terms is one element in strengthening motivation. If students know early on what they will gain from the learning, they can evaluate the benefits it will provide for them. If the benefits are sufficiently appealing, the student will be motivated; if not, little learning will take place.

- Goals must appear to be obtainable; if the learning task is complicated, intermediate goals should be established.

- Motivation is enhanced by frequent reporting of progress on the learning task. While researchers believe that assistance is better than criticism for poor performance, most agree that the failure to provide any feedback is most detrimental of all.

- All other things being equal, motivation will be higher when an early use of the learning in attaining some goal is anticipated. A crude implementation of this maxim comes when the instructor threatens a quiz following the lecture, but the principle holds true for more subtle approaches, too.

- Practice is helpful to sustain motivation, particularly when it does more than cause repetition of previous activities. Tyler speaks of sequential practice, wherein each practice has some element that goes beyond the activities carried out before. (Unfortunately, it appears that there is some mismatch between the theory of sequential practice and the actual construction of most "drill and practice" exercises.)

- The line between too easy and too hard in a learning task is a thin one, but one that must be carefully walked by the instructor and the materials. Too easy (boring) or too hard (hopeless)--in either case, the all important motivation is destroyed. (There seems to be some support for motivation being optimized when the students are pressured to do a little more than they feel perfectly comfortable with.)

Dr. Butler and a considerable number of other writers view the previous two concerns--individual differences and motivation--to be so important that the other factors (discussed below) are considered simply as strategies for effectively handling individual differences and sustaining motivation. Nowhere in the literature are these two factors viewed as anything less than critically important concerns. With that as a preface, let us review the remaining conditions for learning.

Organization

- Materials and instruction must be presented with structure. The student facing a new learning task cannot be expected to know how to organize the information in such a way that it can be handled effectively.

- The structure must not only organize the new learning into suitable specific patterns and relationships, it must also integrate the learning into the student's previous base of knowledge. It is considered best to relate the new task to previous learning as quickly as possible.

- Since new learning can only take place using the existing knowledge of the learner, new concepts and vocabulary must be explained using the existing conceptual and vocabulary base of the learner.

- It is difficult for the learner to separate underlying principles from small details. Thus, learning is generally better if the complexities and details of the learning are saved until after the major principles have been described and applied.

- Reviews and summaries help strengthen instruction when they are provided at logical intervals in the learning. The reviews and summaries should reinforce the organization which should be consciously included in all aspects of the learning task.

- Learning is enhanced if the materials and concepts can be put into patterns meaningful to the student. Isolated pieces of information will seldom be retained.

- Some ways of organizing learning are better than others, in large part because they have a better "anchor" in the student's existing knowledge base. Instruction proceeding from simple to complex is one obvious example. Butler lists seven more "rules of thumb" for organizing instruction:

  a. From the familiar to the unfamiliar
  b. From the present to the past
  c. From the how to the why
  d. From the fundamental, to the related, to the tangential
  e. From the general, to the specific, back to the general
  f. From deductive to inductive
  g. From overview, to the details, back to overview.

Participation

- Teachers do not make students learn. Students learn only by their own actions. Thus, any competent instructional process will involve the student continuously. The instruction must contain techniques to ensure that students are actively engaged in learning, since this is the only way learning will take place. (While this is a very broad generalization, it appears to have near unanimous support from learning theorists.)

- Application of the new learning at frequent intervals will enhance retention of the learning and will help the learner to verify the validity of the new concepts.

- Questions cause participation and thus questions should be included in the learning activity. The questions need not be in tests or quizzes to be valuable; they can be interspersed in any learning activity as long as steps are taken to ensure that they are actually considered by the student.

- Learning a procedure can be improved by having students try incremental portions of the procedure, even if only to verbalize or visualize the procedure. This incremental application of the learning is much superior to a single application following conclusion of all the learning tasks.

- Any learning activity for the student should be carefully structured to avoid consideration of relatively minor details early in the learning task. The first trial should encompass only the most important factors.

- Trial and error learning appears to be significantly inferior to performing the task correctly at the outset. Thus, the learning activity should use prompts and other techniques to minimize the probability of incorrect performance by the student.

Feedback

- Students continue at what they do well when they know they have done well. Conversely, students will avoid the things they do poorly. But when they perform poorly, students will change their behaviors to try ways to achieve success. Only when they consistently find that nothing works will they stop participating and thus cease to learn. It is therefore incumbent upon the developer of a learning activity to guarantee that the successful student receives notification of that success, and that the unsuccessful student receives the prompts and additional information necessary to increase the probability of achieving success.

- Feedback is always important, but feedback that simply lets students know they were or were not successful is much less valuable than feedback which provides an explanation of why the performance was correct or incorrect.

- One key to effective feedback is to minimize the chance of error by the student. The feedback provided to the students should reinforce successful behavior and provide the explanations necessary to change unsuccessful behaviors to successful ones.

- The feedback can come from materials, instructors, peers, computers, etc., but the source of the feedback must know that the feedback was received and applied by the student. Thus, instructors and other "presenters of learning" must have timely ways of verifying the feedback has worked effectively and that the chance of student error is minimized.

Repetition and Reinforcement

- Repetition is useful if for no other reason than it increases the time available for learning. But learning through repetition is effective only under the conditions required for any learning--high motivation, good organization, an attentive student, etc. If these conditions are not present, the repetition will be ineffective and perhaps harmful.

- Overlearning (continuing to study or practice after attaining proficiency) is held by most researchers to be an important requirement for long-term retention. There are, however, no convenient rules for the type and amount of repetition which is optimal. The developer should be aware that overlearning will not be effective if the activity squelches motivation.

- As emphasized earlier, learning is more likely to be retained when it has been linked by the student to established elements of the student's knowledge base. This is why isolated knowledge is soon forgotten, while knowledge of equal complexity related to a broader base of information and experience is retained. Thus, any overlearning activities should be carefully examined to ensure their relationship to previously established learning, as in the method of sequential practice discussed earlier.

- Practice and review should be spread over time. Both concentrated repetition of the learning activity early on and review over longer intervals is helpful. However, it is clear that two hours of consecutive practice is by no means twice as good as one hour. (In fact, Butler states that any practice session over 30 minutes is "open to question".) Both initial overlearning activites and repeated reviews are important, but they must meet the criteria necessary for any learning activity, including maintenance of adequate motivation.

Generalizability

- Generalizability is a key to effective growth and learning. It is impossible to teach a student all the specific knowledge and skills necessary to meet all possible circumstances. The only solution lies in providing the student with generalizable knowledge and skills and an opportunity to utilize them. It is, therefore, very important that instruction and instructional materials do not stop with conveying information; rather, they must help the student explore the generalizability of the information.

- It is not enough for the student to learn generalized principles. The ability to generalize is not automatic, and students must have instruction and practice in how to generalize if the learning is to be as valuable as possible.

- Rote learning is antithetical to generalization. While there are some cases where rote learning is a useful means of acquiring names, dates, etc., the transfer of learning to the broadest number of situations is a much more desirable situation. Rote learning and rote practice activities should generally be avoided.

- The materials or the instructor must show how a concept is applied to a number (Butler says "a minimum of three") of sample contexts. Students must then have practice applying the learning, and the practice must be monitored to assure adequate transfer of the concept.

- Generalization is desirable, and the path to generalization is frequent extension of the learning to new circumstances. Learning activities should be structured to provide opportunities and encouragement for the extension of skills and information as much as practical.

Whether the above listings are viewed as the elements of a learning theory or as the design considerations of instructional development is immaterial. In either case, the important fact is that some ways of providing learning are better than others, and that some ways are no good at all. The literature of educational technology is, as discussed earlier, very diverse, but yet there seems to be near unanimous support for structuring learning activities to fit what seems to be a very important set of conditions for learning. Most educational technologists and instructional theorists would advocate that the types of concerns presented in this section be considered long and hard in any educational design and development activity.

V. IMPLEMENTATION CONCERNS RELATED TO EDUCATIONAL TECHNOLOGY

The point was made earlier that sound instructional design is not entirely adequate to ensure the success of a technology-based educational product--that the project has to deal with a whole host of implementation concerns, some uncontrollable.

The design concerns/learning theory elements discussed in the previous section seem to appeal more to educational technology writers than the implementation concerns under consideration now. There is less written about implementation concerns by such people and what is written is more essay than research. Thus we have turned to the research on the diffusion of innovations for most of what is written in this section. First, however, a summary of factors affecting implementation written by an educational technologist will help set the stage for applying the research findings on innovation diffusion to this context.

An Educational Technologist's View of Implementation

In the essay "Musings Of An Educator-Technologist, or I Never Could Get My Mother To Understand What I Did For A Living"[5], Albert L. Goldberg presents 45 propositions, aphorisms, and lessons learned dealing with the past, present and future of technology, education, and educational technology. Dr. Goldberg's list could not be considered solid facts about educational technology implementation but rather the informed opinions of an expert in the field. The essence of these observations can be found in the writings of several other authors with

[5]Goldberg, A.L. Musings of an educator-technologist, or I never could get my mother to understand what I did for a living. Educational Technology, 1980, 20(1), 29-36.

expertise in the field. Thus, if used with some care, the ideas should be of use when implementing a technology-based educational process or product.

Thirty of the 45 propositions Goldberg advances seem applicable to our situation. Incidentally, the four categories under which the propositions are arranged are arbitrary classifications not in Goldberg's listing; also, there is no significance in the ordering of elements within or between catgories.

Apparent Truisms About Technology In General

1) There is the assumption that if a technology is available, it should be used.

2) There is the notion that each new technology will provide salvation. This notion is held by the public and by educators as well.

3) Vendors provide packages and systems; practitioners need solutions to problems.

4) Technology offers technique but not experience, judgment or wisdom.

5) The technological revolution in education promised in the years following World War II is largely unrealized.

Conditions Of Educational Technology Development

1) The products of technology come mainly from business and commercial sources. There is little involvement of educators and curriculum developers.

2) Technology in education has generally learned little from its application in other settings, e.g., business, industry, the military, etc.

3) It is crucial to separate the needs and possible applications of technology for administration and management functions from the needs and applications for teaching and learning.

4) Technologists have focused on more effective delivery systems for messages, without apparent concern with the content of the messages and their potential applicability.

5) The work of the teacher and the administrator has less of a mechanistic quality than technologists, systems designers, engineers and data processors assume.

6) There is a need for a new "conventional wisdom" of educational technology that incorporates what we may have learned over the past 25 years.

Propositions About Implementing Educational Technology

1) The virtues and potential benefits of each new technology are generally oversold.

2) New technologies do not immediately displace older technologies.

3) Technologies are essentially value-free and apolitical; which technology to apply in what setting at a particular point in time, though, often becomes a political decision.

4) Technology offers rational approaches; its application is confounded by the fact that organizational processes are to a large degree irrational and idiosyncratic.

5) Educational innovations involving technology have appeared to be composed of short bursts of enthusiasm centered on a particular technology. Such temporary passions have not facilitated entrance of the innovation into the educational mainstream and have not materially affected what happens in education.

6) The application of technology in education presents additional problems over and above the technology itself which neither the planners nor the installers could have contemplated.

7) Schools and other formal agencies exhibit (as institutions) a high degree of inertia in adapting to changes that involve the application of technology.

8) Educational technology tends to have more immediate applicability in environments where a training methodology is invoked, rather than in programs which espouse educational purposes.

9) To practitioners, every quantum jump in technological capability carries an implicit threat to their personal and professional world, to what they do, to what they may do.

10) Educational technology must be viewed as having different benefits and expectations for and by various potential users.

11) Large-scale demonstrations and research findings have remarkably little effect on what practitioners do.

Current Educational Conditions And Resources For Educational Technology

1) Information should be regarded as a prime resource in the educational setting, one that needs planning, maintenance, evaluation and management at the highest level.

2) Educational institutions, as others, will be plagued by increasing needs for record keeping and aggregating present as well as new data for internal operations, and for a proliferation of new external agencies which have a monitoring function.

3) The practitioner/researcher gap continues to widen. There is a paucity of research to inform and to improve practice, and there are few mechanisms to evaluate and disseminate research of value.

4) As long as the goals of education and its priorities are under attack from without, and stressed and conflicted from within, educational agencies will have continuing problems of finance, maintenance, morale, long-range planning, risk taking and selling to the public.

5) Educational and political agencies are social inventions; they can be dis-invented.

6) Funding agencies attempt to deal with problems at the wholesale level; practitioners work at retail.

7) Funding sources today put a premium on objectives that stress immediate payoff.

8) The press for immediate payoff of innovations, including technology, and for technological "quick fixes" obscure the need for attention to problems which are ascribed to fundamental research, i.e., learning theory, research methodologies, and curriculum inquiry.

With Goldberg's propositions about educational technology as a basis, let us now turn to a review of a different set of literature to see what can be learned about the successful diffusion and adoption of innovations.

Considerations Drawn from the Diffusion of Innovations Literature

Although our literature search on the diffusion of innovations revealed a large number of research studies on this topic, a key finding

was a book published in 1971 titled Communication of Innovations: A Cross Cultural Approach.[6] This book is essentially a distillation of the findings of over 1500 diffusion publications produced prior to the 1970's. Our review of the research conducted since then did not reveal significantly different findings from those reported in the book, at least as we felt they related to the diffusion and implementation of educational technology. Thus the following information is drawn from this book unless otherwise noted. Rogers and Shoemaker's book covers the full gamut of innovations from trying to persuade people in an isolated jungle tribe to boil their water to the implementation in a cosmopolitan, contemporary setting of a new communications system. To find this section useful, one must accept the notion that the findings of this broad-based research can be applied to the implementation of educational technology. The following topics will serve to organize the relevant ideas related to our implementation concerns.

1) Decision-making processes surrounding use of an innovation
2) Attributes of an innovation affecting adoption rate
3) Personal characteristics of innovation adoptors
4) The role of opinion leaders in innovation adoption
5) The role of change agents in innovation adoption
6) Communication channels affecting innovation adoption

[6]Rogers, E.M, & Shoemaker, F.F. Communication of innovations: A cross cultural approach. New York: The Free Press, 1971.

Decision-Making Processes

One of the first ways in which research on the diffusion of innovation helps us is to provide models for the mental process individuals go through from first learning of an innovation to full fledged committed use.

Consider three types of innovation decisions:

A) Optional decisions made by an individual regardless of the decision of others.

B) Collective decisions made by consensus by a group of individuals.

C) Authority decisions forced upon an individual by someone in a higher position of power.[7]

The stages in the three decision-making processes are contrasted in Table 2. The discussion which follows gives most emphasis to the optional individual decision since the concepts embedded there lend understanding to the other situations.

[7]At times, actual adoption of an innovation may require more than one type of decision. For example, it may be that a collective decision by an entire school faculty would need to be made about adopting new teaching methods before an individual teacher could make a decision about what to use in his/her classroom.

Table 2 [9]

Stages in Three Innovation Decision-Making Processes

Optional Individual Decisions	Collective Decisions	Authority Decisions
1. Knowledge (especially awareness knowledge about the innovation)	1. Stimulation of interest in the need for the new idea (by stimulators)	1. Knowledge about the need for change and the innovation (by the decision unit)
2. Knowledge (how-to and/or knowledge of underlying principles)	2. Initiation of new idea (by initiators)	2. Persuasion and evaluation of the innovation (by the decision unit)
3. Persuasion (individual forms favorable or unfavorable attitude)	3. Legitimation of idea (by power holders or legitimizers)	3. Decision concerning acceptance or rejection of the innovation (by the decision unit)
4. Decision (individual engages in activities leading to a choice)	4. Decision to act (by members of the social system)	4. Communication of the decision (to adoption units in the organization)
5. Action and Confirmation (individual seeks reinforcement for decision made)	5. Action or execution of the new idea	5. Action or implementation of the decision (by the adoption unit)

[9] Adopted from Rogers and Shoemaker, 1971, pp. 276 & 305.

A. Optional Individual Decisions. There are four stages an individual goes through when contemplating adoption of an innovation: knowledge, persuasion, decision and confirmation. The early stages of an individual's decision about an innovation begins with acquiring knowledge. First is awareness knowledge--a person is exposed to the existence of an innovation and gains some understanding of how it functions. Research suggests that individuals tend to expose themselves selectively to ideas consistent with their interests, needs or existing attitudes. The spread of awareness knowledge of an innovation is more rapid than the innovation's adoption rate.

Another important kind of knowledge is "how-to" knowledge--information necessary to use an innovation properly. A more general type of knowledge deals with the underlying principles related to the innovation. It is generally possible to adopt and use an innovation without this latter knowledge but the long-range competence of individuals to judge future innovations is facilitated by knowledge of principles.

At the persuasion stage of the decision process, the individual forms a favorable or unfavorable attitude toward the innovation. At the knowledge stage the mental activity is mainly cognitive whereas at the persuasion stage it is affective (feeling).

At the persuasion stage the individual becomes more psychologically involved with the innovation and actively seeks information about it. People's personality and social norms may affect where they seek information, what messages they receive and how they interpret the information received. The perceived relevant advantage, compatibility, complexity and other characteristics of the innovation are especially

important in shaping a person's attitudes. Note also that there are at least two levels of attitudes: (1) a general attitude toward change and (2) a specific attitude toward the innovation.

At the decision stage, the individual engages in activities which lead to adoption or rejection of the innovation. For example, most individuals will not adopt an innovation without a probationary tryout to determine its utility for their situation. How-to knowledge becomes particularly important at this point.

Bear in mind that the decision to adopt or reject an innovation and the actual use or non-use of it are different behaviors. In the case of optional individual decisions (those being discussed in this section) these two behaviors usually occur concurrently in the same individual. However, in the case of authority decisions, the decision to adopt or reject and the use or non-use of the innovation may be conducted by different individuals and the two events (decision and use) may not occur at the same time.

At the confirmation stage, a person seeks reinforcement for the decision made previously but may reverse the decision if exposed to conflicting messages about the innovation. This stage continues for an indefinite period of time. Throughout the confirmation time the individual attempts to reduce dissonance aroused by the decision. If conflicting messages are received, the person may discontinue use by adopting a better innovation or simply rejecting it because of dissatisfaction with its results.

Another concept worth noting at this point is the diffusion effect--the cumulatively increasing degree of influence upon an individual to either adopt or reject an innovation. This influence results from the

person's increasing rate of knowledge about the innovation, and adoption or rejection of the innovation elsewhere within the social system. Research indicates that until at least 20 or 30% of the people have awareness knowledge, there is almost no adoption. Once this threshold is passed, increases in awareness knowledge lead to increases in adoption. The diffusion effect appears greater in social systems interconnected by interpersonal communication channels.

Note also that over-adoption (adoption of an innovation by an individual when experts think it should be rejected) may occur. This may be due to insufficient knowledge about the innovation on the part of the adopter, inability to predict its consequences or a mania for the new.

B. Collective Decisions. A collective decision is actually composed of a multitude of individual decisions but the different stages of the process may be carried out by different persons (see Table 2). In the case of optional individual decisions, all of the decision-making stages occur within one person's mind.

The types of people involved at each stage in a collective decision appear to differ. For example, stimulators of collective decisions are more sophisticated or urbanized than others, thus having easier access to innovations and greater ability to perceive needs and problems of the social system. The initiators of collective decisions are unlikely to be the same individuals as the legitimizers. Initiators are noted for their intimate knowledge of the system and favorable attitude towards change. Legitimizers are the high status power holders of the system who sanction the change. The rate of adoption of an innovation made through a collective decision is positively related to the degree to which the legitimizers are involved in the decision-making process and the degree of power concentration in the social system.

As with authority decisions, member satisfaction with and acceptance of collective decisions is positively related to the degree of their participation in the decision. It is also positively related to member cohesion within the social system.

C. Authority Decisions. Authority and optional individual decisions represent two extremes on a continuum representing the influence of the social system on a person's decisions. Authority decisions are commonly found in formal organizations--organizations deliberately established to achieve predetermined goals. Such organizations are characterized by prescribed authority roles in a formally established system of rules and regulations which govern the behavior of its members. Of course, informal practices, norms and social relationships also exist among its members.[9]

Rogers and Shoemaker concluded that knowledge about the need for change and the innovation can come both from sources internal and external to the organization. Ideas communicated upwards from subordinates to their superiors are often problem prone and depend largely on the nature of the relationship between the two parties. A supportive relationship between the subordinate and the person in a higher position leads to more upward communication about the innovation. Participation in decision making by the subordinate (eventual adopter) is very positively related to his/her attitude toward and satisfaction with the authority decision.

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[9]Diffusion researchers have largely neglected situations involving authority decisions, although considerable research has been done in the last few years on organizational change. That research has not been included in this review but can be in a revised version of this paper if the Design Team so desires.

Rothman, Erlich and Teresa,[10] when discussing how to promote innovation, emphasize the importance of affecting an organization's goals. They state that research indicates that the dominant goals of an organization reflect the influences and vested interests of the most powerful people and groups in the organization. To change an organization's goals, two approaches are suggested:

1. increase the power of the groups within the organization that hold goals compatible with those of the desired change
2. introduce new groups into the organization that hold compatible goals.

Perceived Attributes of Innovations

It is important to emphasize that it is the potential adopter's perceptions of the attributes of an innovation, not the attributes as classified by someone else, which affect an innovation's rate of adoption. The following five attributes of innovations seem to be related to their degree of adoption. The first four are positively related to an innovation's rate of adoption; the last one is negatively related.

1. Relative Advantage--the degree to which an innovation is perceived as better than the idea it supercedes. The relative advantage of a new idea may be increased by a crisis, thus affecting its rate of adoption. Subdimensions of relative advantage worth noting include:

   a) the degree of economic profitability
   b) low initial cost
   c) lower perceived risk
   d) a decrease in discomfort
   e) a savings in time and effort
   f) the immediacy of the reward

2. Compatibility--the degree to which an innovation is perceived as consistent with (a) existing values, (b) past experience and (c) needs. Compatibility insures greater security and less risk to the receiver.

[10] Rothman, J., Erlich, J. & Teresa, J. Promoting innovation and change in organizations and communities. New York: John Wiley & Sons, Inc. 1975.

3. Trialability--the degree to which an individual may experiment with an innovation on a limited basis.

4. Observability--the degree to which the results of an innovation are visible to others.

5. Complexity--the degree to which an innovation is perceived as relatively difficult to understand and use.

Personal Characteristics of Innovation Adopters

All individuals in a social system do not adopt an innovation at the same time. Adopters can be classified into categories on the basis of when they first begin using a new idea. The dominant trait of people within each of these categories is underlined in the discussion below.

1. Innovators

Venturesomeness appears to be almost an obsession with innovators. They are eager to try new ideas and desire the hazardous, daring and risky. Communication patterns and friendships among a clique of innovators are common, even though the geographical distance between them may be great. Being an innovator has several prerequisites, including control of substantial financial resources to absorb the possible loss due to an unprofitable innovation, the ability to understand and apply complex technical knowledge, and willingness to accept an occasional setback when an adopted idea proves unsuccessful.

2. Early Adopters

The early adopters are respected by their peers and are considered successful and discreet users of new ideas. They are a more integrated part of the local social system than are innovators. In most social systems, this adopter category has the greatest degree of opinion leadership of any category. Potential adopters look to early adopters for advice and information about the innovation.

3. Early Majority

The early majority adopt new ideas just before the average person of a social system. They interact frequently with peers but rarely hold leadership positions. The early majority are people who deliberate for some time before completely adopting a new idea.

4. Late Majority

The late majority adopt new ideas just after the average member of the group. Adoption may be both an economic necessity and the answer to increasing social pressures. Although they can be persuaded of the utility of new ideas, they are skeptical and the pressure of peers is necessary to motivate adoption.

5. Laggards

Laggards, the last to adopt innovation, are very traditional. Opinion leaders are almost never found among them. They are the most localite in their outlook of all adopter categories; in fact, many are near-isolates. Their point of reference is the past, with decisions being made in terms of what was done by previous generations.

It would be too cumbersome to attempt to contrast all five adopter categories on further characteristics. However, research suggests that compared to later adopters, relatively early adopters tend to have:[11]

a) more education
b) a higher social status
c) more upward social mobility
d) more specialized responsibilities
e) greater empathy
f) less dogmatic attitudes
g) greater ability to deal with abstractions
h) greater rationality
i) more favorable attitudes toward change, risk, education and science
j) less fatalistic attitudes
k) higher achievement motivation scores
l) higher aspirations for their children
m) more social participation
n) greater integration with the system
o) more sophistication
p) more change agent contact
q) more exposure to both mass media and interpersonal channels
r) greater desire to seek information
s) higher knowledge of innovations
t) more opinion leadership.

[11]Only traits which seem relevant to the use of educational technology are included in this list.

Opinion Leadership

Opinion leadership is defined as the degree to which an individual is able to frequently and informally influence other individuals' attitudes or behavior in a desired way. It is important to remember that opinion leaders can either favor or oppose an innovation.

Compared to followers, opinion leaders have:

a) greater mass media exposure
b) more sophistication
c) greater change agent contact
d) greater social participation
e) higher social status
f) more of an innovation orientation
g) closer conformity to a system's norms.

When a system's norms favor change, opinion leaders are more innovative; when norms are more traditional, they are not especially innovative.

Change Agentry

Most change is not a haphazard phenomenon but the result of carefully planned actions by change agents. A change agent is a professional who influences decisions in a direction deemed desirable by the agency attempting change. The change agent functions as a communication link between the change agency and the system it is attempting to influence (the client system).

Change agents tend to fulfill several roles in the change process. They are often the ones who develop a need for, orientation toward and intent to change on the part of potential users of an innovation. They diagnose a person's or client system's problems and translate intent to change into action. Before terminating their change relationship, they attempt to stabilize the change which has been made.

Although research shows that most change agents tend to concentrate their efforts on creating awareness knowledge, they would likely use their energies more effectively if they concentrated on how-to knowledge. Awareness knowledge can generally be communicated more efficiently by mass media channels.

Since experience with one innovation carries over to a person's feelings about another innovation, research suggests that change agents should begin their activities among a particular group of people with an innovation that possesses a very high likelihood of success (e.g., has a high degree of relative advantage and is compatible with existing beliefs). Such an approach can result in the development of a positive general attitude toward change on the part of clients.

Change agents possess qualifications which allow them to act as stimulators and initiators of collective decisions, but seldom can they be decision legitimizers; they lack the high status, social power and established credibility that a power holder must have to sanction new ideas.

A change agent's success is positively related to the extent of his/her effort and orientation toward the potential user rather than the change agency. The degree to which the innovation is compatible with the users' needs also is positively related to the change agent's success. The extent to which the change agent empathizes with and is similar in interests and roles to the potential users, works through opinion leaders, is credible in the eyes of potential users and increases the users' ability to evaluate an innovation also are positively related to his/her success.

Communication Channels

It is often difficult for individuals to distinguish between the source of the message--an individual or an institution that originates a message--and the channel which carries that message--the means by which a message gets from a source to a receiver. There are certain tasks which one channel can do that others cannot do. Thus, communication channels often can be combined to advantage. Despite their importance, relatively little research has focused on communications channels in the diffusion process.

In the research that has been done, researchers categorize communication channels as either interpersonal or mass media in nature. Research shows that these channels play different roles in creating knowledge and in persuading individuals to change their attitudes toward innovation. They also are different for early and late adopters of new ideas.

Mass media channels are those means of transmitting messages which enable a source of one or a few individuals to reach an audience of many (e.g., radio, television, film, newspapers and magazines). Interpersonal channels are those that involve a face-to-face exchange between two or more individuals. These channels have greater effectiveness than mass media channels when resistance or apathy exists on the part of the person or group receiving the message. The chart on the next page distinguishes the characteristics of these two communication channels.[12]

[12]Chart taken from Rogers and Shoemaker, 1971.

CHARACTERISTICS	INTERPERSONAL CHANNELS	MASS MEDIA CHANNELS
Message flow	Tends to be two-way	Tends to be one-way
Communication context	Face-to-face	Interposed
Amount of feedback readily available	High	Low
Ability to overcome selective processes (primarily selective exposure)	High	Low
Speed to large audiences	Relatively slow	Relatively rapid
Possible effect	Attitude formation and change	Knowledge change

Mass media channels are relatively more important at the knowledge stage of the decision process whereas interpersonal channels are more important at the persuasion stage. Mass media channels are also more important than interpersonal ones for early adopters than for later adopters.

Summary of Diffusion Concerns

The above ideas drawn from research on the diffusion of innovations suggests that educational technologists cannot restrict their thinking to the technology itself if they care about it being implemented in the schools (or elsewhere). They must work in tandem with people responsible for or capable of influencing the technology's use.

Early on in the design stage, the decision makers who will determine adoption and use of the technology must be identified. Those responsible for ensuring successful use must consider how potential users will perceive the technology's relative advantage, compatibility with their values, experience and needs, trialability, observability and

complexity. The personal characteristics of the potential adopters, especially those listed earlier, must be given careful consideration.

The importance and role of opinion leaders and change agents must also be taken into account. And finally, the channels of communication used must be given careful thought to ensure effective and efficient transmittal of information about the new technology.

VI. CONSEQUENCES AND ASSESSMENT OF EDUCATIONAL TECHNOLOGY USE

Responsible educational technologists must not assume their task is done once their technology is implemented in an educational setting. The consequences of its use need to be assessed. Also, the concepts involved in assessing consequences can be important to developers as they design their technology.

Consequences[13]

Consequences of technology may be classified as (1) functional or dysfunctional, (2) direct or indirect, and (3) manifest or latent. The functional consequences are desirable effects of an innovation whereas dysfunctional consequences are undesirable effects. Direct consequences are changes which occur in immediate response to an innovation whereas indirect consequences result from the direct ones. Manifest consequences are changes that are recognized and intended by the members of the social system; latent consequences are neither intended nor recognized.

When consequences are assessed, three intrinsic elements of the educational technology need to be considered:

1) Form--the directly observable physical substance of an innovation.
2) Function--the technology's contribution to people's way of life.
3) Meaning--People's subjective and frequently subconscious perception of the technology.

[13]Ideas in this section are based on Rogers and Shoemaker, 1971.

Assessment Process

When undertaking an assessment of the consequences (or potential consequences) of the use of a particular educational technology, one might consider employing these steps in the assessment process described by Kirchner and Lazerson:[14]

1) Define the assessment task, including scope of inquiry, major problems and ground rules.

2) Describe relevant features of technologies supportive to and competitive with the major technology to be assessed, as well as the major technology.

3) Develop state-of-society assumptions regarding major non-technological factors influencing the application of the relevant technologies.

4) Identify impact areas, ascertaining those societal characteristics that will be most influenced by the application of the assessed technology. (The categories of consequences and elements of the technology listed above may be useful here.)

5) Make preliminary impact analysis by tracing and integrating the process by which the assessed technology makes its societal influence felt.

6) Identify possible action options by analyzing various programs for obtaining maximum public advantage from the assessed technology.

7) Complete impact analysis with an analysis of the degree to which each action option would alter the specific societal impacts of the assessed technology.

Consider a specific example of the use of this process when a panel of experts assessed a computer-assisted instruction package. Potential consequences of use were hypothesized and an analysis of the favorability, likelihood and degree of control of each side effect was assessed. A table like Table 3 resulted.

[14]From Kirchner, E, & Lazerton, N. Technology assessment at the threshold. Innovation, 1972, 27, 16-23.

Table 3

Summary of Selected Effects of
Computer-Assisted Instruction

Impacts on:	
Institutions of higher education:	
Increased cost	fLC[a]
Improved instruction	fLC
Physical plant modification	FLC
Closer ties between schools	FlC
Destructuring of curriculum	Flc
Extended day, week, year	FLc
Need for more TV channels	fLC
Standardization and centralization	FLC
Improved continuing education	FLC
Coping with poorly prepared students	FlC
Students:	
"Impersonal" education	flc
Individualized instruction	FlC
Aid for minority group students	FlC
Student-instructor relationship	Flc
Faculty:	
Modification of instructor's role	FlC
New copyright protection	FLC
Industry:	
Industry-controlled education	FLC
Development of industries and products	FlC

[a] F = Favorable, f = Unfavorable; L = Likely, l = Unlikely; C = Controllable, c = Uncontrollable

Note: This summary was excerpted from "A Study of Technology Assessment" by the National Academy of Engineers, 1969, p. 44 (Impacts and Characteristics of Strategy No. 1).

These consequences have not yet necessarily occurred, but the experts conducting the technology assessment postulated that they could occur on the basis of certain assumed future conditions.

Armed with results such as in Table 3, developers of a computer-assisted instructional system would no doubt look at the likely unfavorable impacts that are within their control to see if there are possible modifications which might reduce the likelihood of unfavorable effects. Once those modifications are made, the same analysis of impacts would be undertaken again. This process could continue until the developers are either (1) confident that their technological application will have as many favorable and as few unfavorable side effects as possible, or (2) convinced that the negative side effects outweigh the potential benefits requiring that plans for the new system be dropped.

Locatis and Gooler[15] propose some other practical suggestions when assessing the consequences of the use of educational technology:

a) Use a broad range of criteria.
b) Utilize adversary proceedings.
c) Assemble multidisciplinary teams.
d) Use existing empirical data and scientific theories.
e) Conduct experiments.
f) Structure assessments so as to separate multiple issues and variables.
g) Estimate priorities.
h) Examine in detail the inherent characteristics of an action being assessed.
i) Explore a broad range of potential consequences.
j) Investigate support systems.
k) Explore possible abuses.
l) Calculate the magnitude of the action or activity being assessed.
m) Estimate the controllability of hypothesized adverse effects.
n) Indicate the amount of uncertainty associated with each hypothesized impact.

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[15]Locatis, C.N, & Gooler, D.D. Evaluating second-order consequences: Technology assessment and education. Review of Educational Research, 1975, 45, 327-353.

Of course, these suggestions may not be useful in all situations. Practical constraints such as time, money, talent of the evaluator and philosophical perspectives affect use. For example, some evaluators may believe the public has little to contribute to the assessment and may involve only experts.

Cost Analysis

Since cost is such an important consideration in educational technology, a few comments on its analysis are in order. There are a number of cost analysis models, complete with formulas, that can be used to evaluate the cost and worthiness of a technology-based learning activity. Some of the models are even suitable for comparing two different learning activities, and most can yield such calculated numbers as cost per student, cost per engaged minute, and even "total cost effectiveness". (Incidentally, there are technical differences between cost analysis, cost benefit analysis and cost effectiveness analysis, but the comments below apply to all three, so no attempt is made to separate them in a precise manner.)

Whether cost analysis and cost effectiveness studies could be useful does not seem to be an issue in the literature. Instead, the issue is whether examinations using existing methods have sufficient validity to be worth the effort. Four of the major threats to valid use of the data in making decisions about educational technology projects are discussed below.

First, it is rare to be able to maintain a good control group for the analysis. Since a new method was developed to be a superior way of obtaining some goal, there is an understandable reluctance to callously tell half the group to continue using the old, "inferior" method. Also,

in many cases, the newly implemented product or process does something new; that is, it is not possible to meaningfully match the new costs with the costs of an equivalent prior method simply because there is no equivalent prior method in existence.

Second, the Hawthorne effect (essentially, a positive reaction to something innovative simply because of its novelty) may be a substantial and uncontrollable influence which makes the actual improvement caused by the innovation hard to measure. This is a considerable problem with educational technology projects which, because of all their "bells and whistles", have a very substantial tendency to cause a Hawthorne effect. (The percentage of educational projects that have been initially successful simply because of the Hawthorne effect is unclear, but some critics of the field would have one believe the proportion is very substantial.)

A third problem is knowing what costs and benefits to assign to a project. Since improved learning for a student does not carry a dollar value, it is impossible to do the type of cost benefit studies prevalent in industry. For example, in the proverbial widget factory, training may be provided which causes a trainee to produce X more widgets per hour, the X widgets per hour being worth Y dollars over the period during which the training is effective. The company can also calculate that the training session costs Z dollars per trainee. In general, if Y is greater than Z, the training program is worth having, and the company will feel that their money was well invested. Contrast this with an educational project which might cost $248 per student per year and which, compared to a control group, improves the students' raw scores on the Acme Mathematics Achievement Test by 3.2 points and on the Boy, Do I Like

School Inventory by 4.5 points. Is the project worth keeping? It is hard to say, since the dollar value of those improved scores is nowhere to be found.

Although the fact that an innovation might reduce labor costs is of great importance in industry, it is of mixed value in education. The realities of educational staffing are such that it is not often politically or practically feasible to eliminate teaching staff. This makes analyzing costs in terms of potential labor savings tenuous at best. As an illustrative example, a special team teaching program in a western state costs approximately eight million dollars a year to continue. The overwhelming percentage of the costs are in salaries for teachers over and above those needed in conventional teaching structures. After careful evaluation, a decision was made that the effects of the program did not warrant that level of expenditure and, thus, the program was discontinued. But the actual monetary savings were probably less than one million dollars, since the nearly five hundred teachers required by the program could not be removed from employment because of union regulations and political concerns. The teachers who became available were used to start a wide variety of new programs (new programs which one could cynically point out will also defy effective cost analysis).

Finally, in many (and maybe most) educational technology projects, the amount of money spent is equal to the amount of money available, rather than the amount needed to solve the problem at hand. The realities of funding for educational technology projects are that a ten million dollar project becomes a five million dollar project at the point when it becomes clear that five million dollars is what is available.

While the situation certainly has implications for educational technology development in general, it is one of the major obstacles to the cost effectiveness studies that most people agree should be done. For what this means is that most projects are not really completed; they are just stopped. So how does a researcher determine the cost versus effectiveness issue? In our five/ten million dollar example, would the addition of the second five million dollars make the program twice as effective? Or would the second five million simply provide the fine tuning that yields the last ten percent of the benefit? Or might it be the case that the first five million just lays the groundwork for the project, while it is the second five million that really does some good? Obviously, it is impossible to know for certain, and thus any cost benefit or effectiveness studies usually tend to lack the "final" cost figure needed for sound decision making.

As mentioned at the outset of this section, it is easy to find ways to calculate and evaluate costs associated with educational technology projects. Yet it is fairly clear that the validity of these methods is not, for any single project, a given. The literature seems to indicate that cost analysis procedures are, in general, worthy of careful consideration, but at the same time the literature indicates that these analyses are no guarantee of meaningful data.

VII. SUMMARY

The preceding sections have been sufficient only to give an overview of the status and methods of educational technology. The literature contains thousands of articles; some articles present sweeping overviews, others present technological minutia. This review has attempted to find a middle ground, although there has been some tendency to prefer the general over the specific.

Aggregation of the generalities leaves us with a somewhat bleak picture. While it would be a mistake to overgeneralize, the review has pointed out that

- Educational technologists do not agree on the critical elements of their discipline.
- Educational technology does not have a common knowledge base that can be used to avoid the pitfalls encountered in earlier projects.
- Educational technologists cannot cite large numbers of successful projects which demonstrate the value of their skills.
- The optimism that was present during earlier educational technology projects is largely gone, replaced by a great concern for the practical.
- The success or failure of educational technology projects may depend on factors which cannot be controlled by project developers.
- Any educational activity which does not adequately provide for motivation and differences among individual students will not succeed even if the application of technology is faultless.
- The implementation of technology-based educational projects is hindered by a variety of myths, unrealistic expectations, and political circumstances that may have nothing to do with the reality of the situation.
- Implementing a technology-based educational project causes a host of second-order results, many of which may be unfavorable or uncontrollable.
- If previous large-scale educational projects are an indication, the costs of substantial technology-based development may be prohibitive in a time of limited resources.

These summary statements are not encouraging, but they are indicative of the host of factors mitigating against successful large-scale educational technology development.

Yet, at the risk of being trite, it must be pointed out that similar problems could be cited for virtually every development effort that we now, in retrospect, consider worthwhile. Airplanes, light bulbs, synthetic fibers, even public education--all of these were rejected as unworkable or overly expensive when first proposed. It is only because certain people failed to weigh the objections as heavily as the majority of "knowledgeable people" that these innovations came to be part of our lives.

The point is that educational technology could be only a few years away from providing the techniques and products needed to vastly improve the quality of instruction but, as with the light bulb, we do not have ways to accurately visualize what could happen.

In the absence of an encouraging history, the decision to support an expanded educational technology would be essentially a gamble, a gamble based much more on future promises than past successes. It falls to innovative and risk-taking educators to sanction and support technology-based educational projects. For while the potential benefits could be immense, such projects clearly have no guarantee of success and thus conflict with the restricted vision and practical orientation required by today's educational circumstances.

APPENDIX

CHECKLIST OF EDUCATIONAL TECHNOLOGY

PLANNING CONSIDERATIONS

In this section, the concepts presented in the previous sections are synthesized and summarized in a checklist which can be used to plan educational technology projects. The checklist can be useful at various times, such as when initially considering the development of a new technology or when planning an evaluation of an existing technology.

The checklist is written in the form of questions asking if certain key elements have been considered in the planning/implementation/evaluation activity. The questions are organized under the same categories as the previous narrative--first design considerations and then implementation considerations.

Questions to Answer Concerning the Design of Educational Technology Products and Projects

1. Are the intended learners' characteristics known and incorporated into the product/project?

2. Will the project allow students to enter the learning process at different points in the process to account for individual differences among students and changes in student characteristics?

3. Is there a way that student self-examination of strengths, deficiencies and goals can be worked into the instruction?

4. Is the instruction structured so that each student will have as much time as he/she finds necessary to master the content?

5. Is attention paid to the necessity of motivating the student, both initially and throughout the instruction? Are tactics designed to gain and keep the student's attention throughout the instruction?

6. Do the instructional materials state the outcome of the learning task in concrete terms that the student will understand and likely find beneficial?

7. Will learning goals appear attainable to the student?

8. Are intermediate goals given to students for complicated learning tasks?

9. Are procedures for reporting progress to the student built into the instruction?

10. Is practice of previously learned content built into the instruction--both early in the learning and over time?

11. Is the instruction neither too hard nor too easy for the intended learner?

12. Are the materials and instruction presented within a structure that will be apparent to the student and will fit in with the structure of previously learned concepts?

13. Are major principles described and applied before details are added to the concept being presented?

14. Are reviews and summaries interspersed at appropriate intervals throughout the instruction?

15. Are the following organizational patterns used when they make sense in presenting instruction:

    - o from simple to complex
    - o from familiar to unfamiliar
    - o from the present to the past
    - o from how to why
    - o from fundamental to related to tangential
    - o from general to specific back to general
    - o from deductive to inductive
    - o from overview to details back to overview?

16. Does the instructional process actively involve the student by asking questions, having students frequently apply what they are learning, and so forth?

17. If students are learning a procedure in the instructional process, can they be trying incremental portions of the procedure throughout the instruction?

18. Is every student activity guided sufficiently so that trial and error learning is minimized?

19. Is feedback on student success provided frequently and in enough detail so that the unsuccessful student knows how to become successful?

20. Are repetition and overlearning worked into the instruction in such a way that they do not destroy student motivation?

21. What is the generalizability of the content in the instruction? Are students encouraged (and taught how) to explore and generalize the information learned?

22. Are rote learning and practice minimized?

Questions to Answer Concerning the Implementation of Educational Technology Products and Projects

1. Is there confidence that the content being presented through a technology-based project is best adapted to that technology, or is there some doubt that the technology is being used because of its newness and perhaps faddishness?

2. Are real attempts made not to oversell the potential benefits of the new product/project?

3. Does the product/project involve the teacher in the instruction in a non-mechanistic way?

4. Have educational technology developers presumed that the decision to adopt new innovations in schools is an optional individual decision when in reality it is more likely an authority or, at best, a collective decision?

5. Do developers provide information about their product/project which allows awareness knowledge, how-to knowledge and knowledge of principles to be gained?

6. Is the new product/project presented in a way that is consistent with potential users' past experiences, interests, values and needs?

7. Has attention been given to the stages of the decision-making process individuals or groups go through in deciding to adopt a new technology?

8. Has the technology been defined in terms of attributes perceived of as important by the intended user rather than as perceived by the developer?

9. Is the product/project designed so that potential users can try out segments of it before the total package is adopted?

10. Has an attempt been made to tie publicity about the new product/project to its relative advantage compared to the thing it might replace?

11. Is the product/process as simple to use as possible, especially for teachers who may view it as a threat to their traditional teaching style?

12. Is the technology such that the results of its use will be visible to others?

13. Are individuals used in the project materials (e.g., a narrator/teacher on a videodisc) viewed as credible sources by and, if possible, opinion leaders among, the group who will be adopting the product/project?

14. Can an estimate be made about who the likely early adopters, early majority, late majority and laggards are in a group contemplating adoption of a new product/project, and different approaches for the different groups be made?

15. Does someone need to serve as a change agent to ensure successful adoption?

16. Has attention been paid to how best to utilize mass media and interpersonal communication channels to ensure successful adoption?

17. Has thought been given to the personality characteristics (e.g., general attitude toward change), social characteristics (e.g., contact with opinion leaders) and perceived needs of the user?

18. If the person who is to adopt the innovation is different from the decision maker, has thought been given to how to address each one?